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Blood Flow in a Pedal Bypass Combined with a Free Muscle Flap

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Objective: *to assess the haemodynamic effect of a free muscle flap on the midterm success of a pedal bypass.*
Design: *prospective consecutive study.*
Materials: *a pedal bypass (autogenous vein graft) combined with a free muscle flap was performed in 13 patients with critical leg ischaemia. The feeding artery of the flap was anastomosed end-to-side to the bypass.*
Methods: *blood flow was measured in the bypass before and after transplanting the flap. Doppler was used postoperatively to assess the patency.*
Results: *the bypass and flap pedicle were patent in 11 cases six months postoperatively. Two grafts were thrombosed and the legs amputated. In the successful group the median (range) blood flow in the bypass was 50 (10–100) ml/min. It increased ($p<0.05$) after transplantation to 64 (20–113) ml/min, being 44 (14–97) ml/min distributed to the foot. Blood flow through the flap was 20 (6–37) ml/min. The two failing grafts had a flow of 30 and 51 ml/min before and 48 and 52 ml/min after transplantation, respectively. Blood flow through the flap was 47 ml/min and 36 ml/min, respectively. In the failure group the free flap received most of the blood supply through the bypass.*
Conclusions: *a free muscle flap connected to an infrapopliteal bypass increases the distal outflow bed and thus decreases the outflow resistance and increases graft flow.*

Key Words: Lower limb; Infrapopliteal bypass surgery; Free muscle flap; Microsurgery; Transit-time flowmetry.

Introduction

Ischaemic tissue defects in the lower extremity may be treated with combined limb revascularisation and free flap transfer.[1–9] However, it is not known whether such flaps affect graft haemodynamics and patency.[10–12] The purpose of this study was to use a transit-time flowmeter to assess the intra-operative, haemodynamic changes occurring in a long infrainguinal bypass graft after transplantation of a free muscle flap and to relate these changes to graft patency and limb salvage.

Materials and Methods

Between August 1997 and July 1999, 309 patients with critical leg ischaemia (CLI) underwent infrapopliteal bypass; 13 patients of whom also had a simultaneous microvascular muscle flap.[13,14] There were 8 males and 5 females, aged from 46 to 69 years, and seven were smokers.

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Vascular evaluation

Angiography

Preoperative angiography was performed and the new Rutherford score[15] was used to classify the distal run-off.

Transit-time flowmeter

Intraoperative evaluation of blood flow was done with a standard transit-time flowmeter, CardioMed 4000 (Cardiomed AS, Oslo, Norway). The flowmeter measures blood flow.[16] The measurements were done in the bypass before and after the transplantation and in the pedicle of the flap after transplantation. The flow measurements were made 20–30 min after opening the graft when the curve on the screen was steady after the administration of papaverine to remove vessel spasm. Heart rate, systolic and diastolic arterial pressure were measured simultaneously.

Colour Doppler ultrasound

Duplex SSA-270A/HG (Toshiba Corporation, Japan) was used postoperatively at 1 week 1, 3 and 6 months to assess the patency of the bypass and the pedicle.

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Table 1. Blood flow (ml/min) in the graft before and after transplantation of the free flap and in the pedicle of the flap after anastomosing to the bypass.

n = 13	Graft before transplantation	Graft after transplantation proximally	distally	Pedicle of flap
Salvaged				
1	10	60	43	23
2	54	105	68	37
3	29	35	15	20
4	55	20	14	6
5	35	25	14	11
6	25	64	42	22
7	71	99	72	27
8	100	113	97	16
9	50	75	44	31
10	44	67	51	16
11	50	64	47	17
Mean	48	66	46	21
SD	24	31	26	9
Amputated				
12	30	48	1	47
13	51	52	14	36

n = number of cases.
SD = standard deviation.

The operation

Femoropedal bypass was performed in 11 patients and popliteopedal bypass in two. All the revascularisations were autogenous vein graft bypass except one which was a composite PTFE/saphenous vein graft. In eleven cases a microvascular *latissimus dorsi* (LD) muscle flap reconstruction was simultaneously performed; in one case a microvascular *rectus abdominis* (RA) muscle flap and in one a microvascular *tensor fasciae latae* (TFL) muscle flap. The arterial pedicle of the flap was anastomosed end-to-side to the vascular graft; the vein pedicle end-to-end to a nearby deep vein.

All patients were on aspirin. All the patients were given 20 ml/kg of 6% hydroxyethylstarch (mean 1080 (SD 190) ml) and Ringer acetate solution (4400 (SD 945) ml) to maintain stable haemodynamics and to get mild hypervolaemic haemodilution with low haematocritic (0.28–0.30). All patients were systematically heparinised during the operation prior to cross clamping for vascular reconstruction. The mean blood loss was 3062 ml with a range from 2 000 ml to 4500 ml. This massive blood loss was due to the fact that actually three operations were performed simultaneously, i.e. vascular bypass, minor amputation and debridement as well as the harvesting and microsurgical connection of the large free muscle flap, all under uncompromised antithrombotic and anticoagulation therapy. Free flap ischaemia time was 80 (SD 27) min. The mean operation time was 437 (SD 71) min. The mean anaesthesia time 531 (SD 77) min.

Table 2. Preoperative angiographic run-off score according to Rutherford's score (1997).

	Score
Salvaged legs	
1	7
2	7
3	10
4	1
5	4
6	10
7	4
8	7
9	4
10	4
11	7
Amputated legs	
12	10
13	10

Statistical analysis

The transit-time data were evaluated by linear models using previous stage and systolic, diastolic pressure and heart rate values as covariates. Since none of the covariates were significant, the analysis was reduced to the *t*-test and Wilcoxon Signed Rank Test and results were the same.

Results

Colour Doppler ultrasound evaluation showed patency of the bypass and pedicle of the flap in 11 cases

6 months after surgery. Two legs were amputated after occlusion of the graft and pedicle on 8th and 90th postoperative day, respectively. The transit-time flowmeter measurements are shown in Table 1. Patients' blood pressure and heart rate during the measurements did not change significantly. In the successful group the median (range) value of blood flow in the vein graft was 50 (10–100) ml/min and significantly ($p<0.05$) increased after transplantation to 64 (20–123) ml/min (Table 1). In this group the blood supply to the foot after transplantation was the same or higher than before transplantation except in case 3 (29 ml vs 15 ml), case 4 (55 ml vs 14 ml) and case 5 (35 ml vs 14 ml) presumably because of vessel spasm despite papaverine injection to the proximal graft.

After transplantation of the free flap blood flow increased in one but did not change in the other vein graft that was to fail. The free flap received 98% of blood supply through the graft in one case and 69% in the other. Blood flow to the flap was lower than or equal to the distal graft flow in the salvaged group (Table 1). In four patients the preoperative distal run-off was very poor (Table 2). Two of them were the failure cases.

Discussion

Although free microvascular flaps are widely performed in reconstructive surgery their effect on the leg haemodynamics is poorly understood. In our previous study using colour Doppler US we prospectively demonstrated that blood flow increases in free muscle flaps up to 3 months postoperatively mainly because of an increase in end-diastolic flow and decrease of vascular resistance.[17,18] Sympathectomy relieves arteriolar vasoconstriction[19–23] leading to arteriolar vasodilation with increased capillary perfusion.[19–21] Increased blood flow might explain some of the known positive effects of free muscle flaps on wound healing and chronic infections.[24,25]

In this study vein graft blood flow increased by some 50% after the transplantation of the free flap is presumably due to a reduction in vascular resistance. The free flap received one third of the total blood going through the bypass. On the other hand the free flap clearly did not compromise the revascularization of the leg. These results suggest that the flap behaves like a distal AV-shunt.[26,27–29]

The two failing grafts had a totally occluded pedal arch which may explain the redistribution of the flow to the flap and the immediate occlusion of the distal graft in one of the patients.[30]

We, therefore, conclude that a free muscle flap when connected to a femorodistal bypass increases the distal outflow bed, reduces outflow bed resistance and thus increases graft flow. Increased blood flow may help to maintain the bypass open in some circumstances.

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